the field gave no immediate results as toxic agents and had no immediate effect upon the reduction of these populations, but in the course of three to five days after their application they reduced these populations remarkably, causing motor paralysis of the insects and death. The effectiveness of these materials continued as the eggs in the plant tissues continued to hatch over a period of several days and the young leafhoppers, upon hatching, began to feed. A series of experiments then carried out by special techniques showed conclusively that these materials had no effect upon the insects directly. But if they were applied to the plant and the insects were then placed upon the treated plant, from a few hours to several days afterward, and were permitted to feed, these insects would die in the manner mentioned above. With the materials used only local areas of the plant were affected in this manner and the plant system as a whole was not affected unless the plant foliage was covered with these materials. This apparently is in keeping with the factor of immunity in plants in general, since the cell is the seat of immunity and the system is usually not affected because of the absence of a circulatory system such as we find in animals.

This immunity effect or plant conditioning was first produced by Bordeaux mixtures and other copper compounds and was reported in 1929[2] and 1930.[3] At this time the writer referred to this condition as a residual toxicity effect. More recently a similar type of induced immunity in plants has been produced by various sulfur materials. The apparent killing effect produced upon the insect is the same as in the case of copper compounds, although the effect upon the plant may be entirely different in case of these two materials.

The results obtained with sulfur were first reported[4] in 1933 when Dr. N. F. Howard, speaking before the Ohio Horticultural Society, cited the work which had been carried on during the preceding season (1932) by the author, under his direction. A more complete report[5] was made by Dr. Howard and the author in January, 1934. More recently it has been found that practically all types of sulfurs will produce this effect in varying degrees upon these plants, although the elemental sulfur materials and those forms in which the sulfur is not changed chemically by physical and chemical processes have given the best results. For instance, dusting sulfur, "dry mix," dry wettable and under some conditions flotation sulfur, will give better results than liquid lime sulfur and colloidal sulfur when used to control the potato leafhopper on bean plants.

A recent article by List and Daniels,[6] of Colorado, reports a similar control of the potato psyllid upon potato and a similar residual effect upon the potato plant as that which has previously been produced by the writer with both Bordeaux mixture and sulfur materials on potato and bean.

The psyllid is a sucking insect closely related to the potato leafhopper and apparently is affected in the same manner by inducing immunity in the plant by chemical treatments.

Although insoluble when placed upon the plant tissue, these materials in some way either cause the plant to produce abnormal quantities of a toxic material which may possibly be produced normally by the plant only in minute quantities, or the chemical effect upon the plant may be direct by causing the character of the sap to change remarkably and the general rate of metabolism to change by the presence of extremely small amounts of the insecticide which has been absorbed in some form by the plant. Experimental work has given evidence of both possibilities.

Materials of this type can scarcely be classified as contact insecticides in the same manner as those materials which kill the insect by direct effect upon the insect's body. It seems necessary, therefore, to classify insecticides which affect insects of this type in two distinct groups: First, those which we have previously designated as contact insecticides and whose toxicity value refers to the direct insecticidal action upon the insect through contact; and, second, those which might be said to have a residual toxicity value which is attributed to an indirect effect since the toxicity is accomplished by a conditioning or partial conditioning of the plant (accessory to a certain possible inherent partial immunity) to produce a killing effect upon the insect.

Such a principle of toxic effect or insecticidal relationship—that of working through the plant and producing induced insecticidal immunity in the plant—has not received much positive support or serious consideration until this recent work of the past eight years has demonstrated conclusively these results.

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PHYSICAL RELATIONSHIPS BETWEEN MARSH AREAS AND LAKE LEVELS

IT seems to be quite a common assumption that receding lake levels are due to deforestation and cycle changes in precipitation. Similarly, marsh levels are usually supposed to be dependent upon the levels of adjacent bodies of water and streams. The writer is

2 *Jour. Econ. Ent.*, 22: 345, April, 1929.
3 *Jour. Econ. Ent.*, 23: 383, April, 1930.
4 Proceedings of the Ohio Vegetable Growers Association, p. 141, March, 1933.
5 *Florida Grower*, 42: 8, 1934.

6 SCIENCE, n. s., 79: 2039, January 26, 1934.

of the opinion that these assumptions are inadequate, and that there is a further and possibly more important relationship.

Six connecting lakes in Northern Wisconsin were studied for the purpose of determining the vertical fall of the lakes over a period of years. It was found that a low rate of recession had been going on over a period of about 32 years. Very probably this recession can be associated with the timbering operations which were complete about 1894. For the past eight years, however the rate of recession has grown at an alarming rate. Nearly 60 per cent. of the total recession seems to be associated with a time period not greater than eight years, or since 1926. This new rate was calculated as being about eight times as great as the rate effective up to that date. Inasmuch as there have been no great changes in forest cover since 1894, and the precipitation during the past decade has remained nearly constant, it was obvious that some new factor must have entered that lacked explanation.

The clew to this new factor was furnished by an analysis of many conversations with local people. In most cases the low lake levels were mentioned with dry marshes. Further conversation on the marsh conditions disclosed that a good many of the marshes had gone dry in 1926—or the same date that the new rate of recession had started on the lakes. From this the writer assumed that further work on the marsh areas might give some explanation of the lake levels. From the facts given, it is believed that a relationship can be demonstrated that has not been suggested before.

The gradual recession of the lakes over a period of 32 years has already been noted; suppose that the water on the marshes was declining at about the same rate. Then, in 1926, for the first time in recent history, the marshes froze over without surface water on them. This does not mean total dryness, but suggests that there was a minimum of surface water on the marshes. The following spring, the writer believes would bring radical changes to the area. The dry frozen marsh would require less energy to thaw out than the typical wet marsh of former years.

This energy change can be expressed in terms of the specific heats, and the latent heat of fusion of the substances involved.

Given:	Specific heat of clay or sand	0.19
	Specific heat of ice	0.50
	Latent heat of fusion (ice)	80.00

Unit areas of wet and dry marsh.
Cd for depth of clay or sand.
Id for depth of ice.
Tx for temperature change from start of spring thaw until final melting of all ice.

Then the heat requirements for each marsh can be computed. The problem disregards the free water in the soil, which would tend to equalize in each type marsh.

Wet Marsh

$$
\begin{aligned}
I_d \times T_x \times .50 &= H_a \\
I_d \times 80 &= H_b \\
C_d \times T_x \times .19 &= H_c \\
&\overline{\Sigma H_1}
\end{aligned}
$$

Dry Marsh

$$
\begin{aligned}
C_d \times T_x \times .19 &= H_a \\
&\overline{\Sigma H_2}
\end{aligned}
$$

Since ΣH_1 is much greater than ΣH_2, it follows that the wet marsh will require a great deal more heat to thaw out than the dry marsh. Since the total heat available each spring remains more or less constant, the effect of the ratio between ΣH_1 and ΣH_2 would be to demonstrate that the dry frozen marsh would thaw out much sooner in the season than the wet frozen similar areas.

If, then, the dry frozen marsh thaws out early, perhaps in two or three weeks of the early spring, does it not follow that the marsh will allow precipitation to seep vertically through the marsh into the deep water tables below? The wet frozen marsh, the writer believes, acts as a very effective barrier to vertical drainage, and forces the water laterally into the higher water tables, to stagnant pools, and finally into the brooks and streams that are tributary to the lakes.

This presentation does not allow for numerous variables that would enter into the problem. The writer believes, however, that if further detailed field study were done, there could be shown a high correlation between decreasing thaw periods for marshes and decreasing lake levels. It could also be demonstrated that the thaw period of a marsh is largely dependent upon the water content of the soil and the depth of surface water.

The implications of this theory, if acceptable, are numerous. The lakes tend to be dependent upon the marsh areas rather than the usual converse of this. The theory suggests that, if the marshes now dry could be frozen wet, lake levels could be raised. If marshes can be made to retain enough water over the summer months, it seems plausible that surface drainage could be restored. It would indicate to practical conservationists that it is fully as important to confine water on the surface of marshes as it is to retain water in lakes by means of dams. The theory may demonstrate enough dependence of lakes on marshes to change the economic use of marsh lands over a large area.

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BOOKS RECEIVED

RICE, VICTOR A. *Breeding and Improvement of Farm Animals.* Second edition. Pp. xiii + 516. 140 figures. McGraw-Hill. $4.00.

SMITH, DAVID E. *The Poetry of Mathematics and Other Essays.* Pp. 91. Illustrated. Scripta Mathematica, Yeshiva College, New York.

WEDDERBURN, J. H. M. *Lectures on Matrices.* Pp. vii + 200. American Mathematical Society.